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Indian Standard

GUIDE TO CALCULATION OF RESISTANCE OF PLAIN AND TINNED COPPER CONDUCTORS OF LOW FREQUENCY CABLES AND WIRES

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GUIDE TO CALCULATION OF RESISTANCE OF PLAIN AND TINNED COPPER CONDUCTORS OF LOW FREQUENCY CABLES AND WIRES

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Indian Standard

GUIDE TO CALCULATION OF RESISTANCE OF PLAIN AND TINNED COPPER CONDUCTORS OF LOW FREQUENCY CABLES AND WIRES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 11 September 1981, after the draft finalized by the Wires and Cables for Electronic Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard lays down a method of calculation of resistance of copper conductors used in LF wires and cables. This will serve as a guide for calculation of resistance values to be specified in detail specifications for LF wires and cables.

0.3 While preparing this standard, assistance has been derived from IEC Pub 344 (1980) 'Guide to the calculation of resistance of plain and coated copper conductors of low-frequency cables and wires'. International Electrotechnical Commission (IEC).

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard gives a general method for calculating the resistance of copper conductors of low frequency cables and wires for telecommunication.

NOTE — The formulae specified for the calculation of resistance are for dc resistance.

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*Rules for rounding off numerical values (*revised*).

2. GENERAL METHOD OF CALCULATION

2.1 Maximum conductor resistance R at 20°C of insulated copper conductors is equal to:

$$R = R_0 k_1 k_2 k_3 k_4 \quad \text{ohm/km}$$

NOTE — The temperature coefficient of resistance of copper for any temperature t_0 above 0°C shall be taken as $\frac{1}{234 \cdot 45 + t_0}$

where

$R_0 = \frac{21 \cdot 95}{nd^2}$

n = the number of strands in the conductor (for a solid conductor $n = 1$);

d = the nominal diameter of the strands in the stranded conductor, in millimetres, or, for a solid conductor, its nominal diameter;

k_1 = a factor depending on the diameter of the strands and on tinned or untinned conductor;

NOTE — Values for k_1 are given in Table 1.

k_2 = a factor depending on the type of conductor;

NOTE — The value is equal to:
a) 1·00 for solid conductors, and
b) 1·04 for stranded conductors;

k_3 = a twisting factor depending on conductor dimension and the way the insulated conductors are twisted together (for single wires $k_3 = 1$); and

NOTE — Values for k_3 are given in Table 2.

k_4 = for cables with more than one cabling element, a cabling factor depending on conductor size and on the way the cabling elements are assembled; or for cables with one cabling element and for screened wires up to and including five insulated conductors, an elongation factor depending on conductor size (for single wires $k_4 = 1$).

NOTE — Values for k_4 are given in Table 3.

2.1.1 Values for R, calculated according to the formulae, are given in Tables 4 and 5. The values are given with six significant figures.

NOTE — The resistance values in detail specifications shall be chosen from Tables 4 and 5, rounded off to the nearest value and indicated to three significant figures for R below 1 000 ohms and to four significant figures for R beyond 1 000 ohms.

TABLE 1 VALUES OF FACTOR k_1

(*Clause* 2.1)

MAXIMUM DIAMETER OF STRANDS IN CONDUCTOR mm	SOLID CONDUCTOR		STRANDED CONDUCTOR	
	Tinned	Untinned	Tinned	Untinned
(1)	(2)	(3)	(4)	(5)
Over 0·05 up to and including 0·10	—	—	1·12	1·07
Over 0·10 up to and including 0·31	1·08	1·05	1·07	1·04
Over 0·31 up to and including 0·91	1·05	1·03	1·04	1·02
Over 0·91 up to and including 3·60	1·04	1·03	1·03	1·02

TABLE 2 VALUES OF FACTOR k_3

(*Clause* 2.1)

TWISTING LAY FACTOR	NOMINAL DIAMETER OF SOLID CONDUCTOR d, mm			NOMINAL CROSS-SECTIONAL AREA OF STRANDED CONDUCTORS S, mm^2		
	$d \geqslant 0·8$	$0·8 > d \geqslant 0·4$	$d < 0·4$	$S \geqslant 0·5$	$0·5 > S \geqslant 0·15$	$S \leqslant 0$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
>16	1·02	1·03	1·04	1·02	1·03	1·04
$\leqslant 16$	1·05	1·06	1·07	1·05	1·06	1·07

NOTE — Twisting lay factor is the ratio of twisting lay to over-all diameter of the twisting insulated conductors.

TABLE 3 VALUES OF FACTOR k_4

(*Clause* 2.1)

TWISTING LAY FACTOR	NOMINAL DIAMETER OF SOLID CONDUCTORS d, mm		NOMINAL CROSS-SECTIONAL AREA OF STRANDED CONDUCTORS S, mm^2	
	$d \geqslant 0·8$	$d < 0·8$	$S \geqslant 0·5$	$S < 0·5$
(1)	(2)	(3)	(4)	(5)
>16	1·02	1·03	1·02	1·03
$\leqslant 16$	1·05	1·06	1·05	1·06

NOTE 1 — Cabling lay factor is the ratio of stranding lay to overall diameter of the assembled layer.

NOTE 2 — For screened wires, k_4 is determined by reference to the value associated with a cabling lay factor greater than 16.

TABLE 4 CALCULATED RESISTANCE VALUES (*R*) FOR SOLID CONDUCTOR

(*Clause* 2.1.1)

NOMINAL CONDUCTOR DIAMETER (mm)	COEFFICIENTS				CALCULATED RESISTANCE (ohm/km)
	k_1	k_2	k_3	k_4	
(1)	(2)	(3)	(4)	(5)	(6)
0·12	1·05	1·00	1·00	1·00	1 600·52
	1·08	1·00	1·00	1·00	1 646·25
	1·16	1·00	1·00	1·00	1 768·19
0·15	1·05	1·00	1·00	1·00	1 024·33
	1·08	1·00	1·00	1·00	1 053·60
	1·16	1·00	1·00	1·00	1 131·64
0·20	1·05	1·00	1·00	1·00	576·188
	1·08	1·00	1·00	1·00	592·650
	1·16	1·00	1·00	1·00	636·550
0·25	1·05	1·00	1·00	1·00	368·760
	1·08	1·00	1·00	1·00	379·296
	1·16	1·00	1·00	1·00	407·392
0·32	1·03	1·00	1·00	1·00	220·786
	1·05	1·00	1·00	1·00	225·073
	1·13	1·00	1·00	1·00	242·222
0·40	1·03	1·00	1·00	1·00	141·303
	1·05	1·00	1·00	1·00	144·047
	1·05	1·00	1·03	1·00	148·368
	1·05	1·00	1·03	1·03	152·819
	1·13	1·00	1·00	1·00	155·022
0·50	1·03	1·00	1·00	1·00	90·434 0
	1·05	1·00	1·00	1·00	92·190 0
	1·05	1·00	1·03	1·00	94·955 7
	1·05	1·00	1·00	1·03	94·955 7
	1·05	1·00	1·03	1·03	97·804 4
	1·13	1·00	1·00	1·00	99·214 0
0·60	1·05	1·00	1·00	1·00	64·020 8
	1·05	1·00	1·03	1·00	65·941 5
	1·05	1·00	1·00	1·03	65·941 5
	1·05	1·00	1·03	1·03	67·919 7
0·80	1·05	1·00	1·00	1·00	36·011 7
	1·05	1·00	1·02	1·00	36·732 0
	1·05	1·00	1·00	1·02	36·732 0
	1·05	1·00	1·02	1·02	37·466 6
1·00	1·04	1·00	1·00	1·00	22·828 0
	1·04	1·00	1·02	1·00	23·284 6
	1·04	1·00	1·00	1·02	23·284 6
	1·04	1·00	1·02	1·02	23·750 3
1·4 (1·38)	1·04	1·00	1·00	1·00	11·987 0
	1·04	1·00	1·02	1·00	12·226 7
	1·04	1·00	1·02	1·02	12·471 3

TABLE 5 CALCULATED RESISTANCE VALUES (*R*) OF STRANDED CONDUCTOR

(*Clause* 2.1.1)

NOMINAL CONDUCTOR CROSS-SECTIONAL AREA (NUMBER OF STRANDS × NOMINAL DIAMETER OF STRAND mm)	COEFFICIENTS				CALCULATED RESISTANCE (ohm/km)
	k_1	k_2	k_3	k_4	
(1)	(2)	(3)	(4)	(5)	(6)
0·035 mm^2 (7×0·08)	1·07	1·04	1·00	1·00	545·222
	1·12	1·04	1·00	1·00	570·700
	1·20	1·04	1·00	1·00	611·464
0·055 mm^2 (7×0·10)	1·07	1·04	1·00	1·00	348·942
	1·12	1·04	1·00	1·00	365·248
	1·20	1·04	1·00	1·00	391·337
0·079 mm^2 (7×0·12)	1·04	1·04	1·00	1·00	235·527
	1·07	1·04	1·00	1·00	242·321
	1·15	1·04	1·00	1·00	260·438
0·124 mm^2 (7×0·15)	1·04	1·04	1·00	1·00	150·737
	1·07	1·04	1·00	1·00	155·085
	1·15	1·04	1·00	1·00	166·681
0·220 mm^2 (7×0·20)	1·04	1·04	1·00	1·00	84·789 7
	1·07	1·04	1·00	1·00	87·235 6
	1·07	1·04	1·03	1·00	89·852 6
	1·07	1·04	1·03	1·03	92·548 2
	1·15	1·04	1·00	1·00	93·757 9
0·340 mm^2 (7×0·25)	1·04	1·04	1·00	1·00	54·265 4
	1·07	1·04	1·00	1·00	55·830 8
	1·15	1·04	1·00	1·00	60·005 0
0·500 mm^2 (28×0·15)	1·07	1·04	1·00	1·00	38·771 4
	1·07	1·04	1·02	1·00	39·546 8
	1·07	1·04	1·02	1·02	40·337 7
(16×0·20)	1·07	1·04	1·00	1·00	38·165 6
	1·07	1·04	1·02	1·00	38·928 9
	1·07	1·04	1·02	1·02	39·707 5
0·560 mm^2 (7×0·32)	1·02	1·04	1·00	1·00	32·484 0
	1·04	1·04	1·00	1·00	33·121 0
	1·12	1·04	1·00	1·00	35·668 7
0·750 mm^2 (42×0·15)	1·07	1·04	1·00	1·00	25·847 6
	1·07	1·04	1·02	1·00	26·364 5
	1·07	1·04	1·02	1·02	26·891 8
(24×0·20)	1·07	1·04	1·00	1·00	25·443 7
	1·07	1·04	1·02	1·00	25·952 6
	1·07	1·04	1·02	1·02	26·471 6
1·000 mm^2 (32×0·20)	1·07	1·04	1·00	1·00	19·082 8
	1·07	1·04	1·02	1·00	19·464 4
	1·07	1·04	1·02	1·02	19·853 7
1·500 mm^2 (30×0·25)	1·07	1·04	1·00	1·00	13·027 2
	1·07	1·04	1·02	1·00	13·287 7
	1·07	1·04	1·02	1·02	13·553 5